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ABSTRACT

Although teachers may sequence instructions carefully, they are unable to respond to the complex unique experience of each individual learner. Divergent production should be an instructional choice that enables individuals to learn through their own recall and idea construction. Learning is problem solving: when individuals do not know how to deal with situations, opportunities for learning are presented. Individuals solve problems through idea production dependent on cognition, memory, evaluation, and personal characteristics. Divergent production stimulates an internal locus of control, self-evaluation, and a creative transfer of learning. If the self-assurance and initiative wrought by divergent thinking were developed in the early years of life, school anxiety and learned helplessness might diminish. Individuals should understand their thinking habits and use them most effectively. Studies of intellectual operations, tasks, and metacognitions may enhance the thought and learning processes of the gifted, mentally retarded, and emotionally disturbed. Divergent production helps all individuals to learn when they have not been adequately instructed and to solve problems when they do not know what to do. These abilities contribute to the unique development of each individual. (NRB)

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DIVERGENT PRODUCTION STIMULATES LEARNING AND TRANSFER

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DIVERGENT PRODUCTION STIMULATES LEARNING AND TRANSFER

Piaget (1972) insists that understanding is invention, and that individual activity is at the core of the learning process. The study of learning, therefore, is a study of the mental abilities at the command of individuals and of the tasks that they do. When learners produce what they know and combine it with what they see, they state new facts, demonstrate skills, and invent original solutions to problems.

Since it is learners themselves who select mental functions, tasks, and previously learned information, the locus of control for these decisions affects what they learn (Thomas, 1980). Even when teachers sequence instruction carefully, they do not respond specifically to the complex unique experience of each learner. Individuals must contribute to their own learning as only they are able to do. Divergent production should be an instructional choice, therefore, that enables them to learn through their own recall and construction of new ideas.

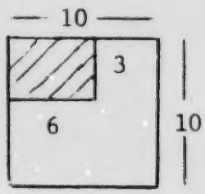
Learning as Problem Solving

Consider what happens when learning is defined as convergent mental action in which individuals apply rules. What is learned? The new performance is recall of a process in which learners use given data. What they learn is how to make substitutions and how to make them more efficiently.

Figure 1 shows an example of thinking done by a student who understood a given situation and an appropriate strategy for dealing with it.

Convergent performance is illustrated here. There is no evidence that learning is in progress.

Question: What part of the square is shaded?



Response: 3 x 6 = 18
10 x 10 = 100

The answer is 18%.

Figure 1 A convergent response to the shaded-square problem

When learners "do not know" how to deal with situations, however, they are presented with opportunities for learning what they did not know previously. To overcome ambiguity, they should first determine what it is that they want to accomplish. Recall Einstein's caution that a problem stated well is half-solved. If learners know what the problem is and what they are to do, they have already taken the first steps toward performance.

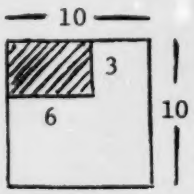
Beyond simple memory, therefore, learning is problem solving. It begins with a search for relations among elements. The search results in new inter-connections between concepts stored in memory (Pellegrino & Glaser, 1979); and divergent production and evaluation replace learned rules. Assuming that they "do not know" what to do, learners define the problem, the process, and the outcome.

These problem solving steps are accomplished through abundant idea production that depends upon (1) cognition (previous and current assimilation), (2) memory (retrieval of both remote and highly pertinent ideas), (3) evaluation (selections of past and present ideas), and (4) personal characteristics (persistence, self-image, independence). To use the strategy well, learners must not only know the difference between following directions and producing ideas, but also be willing to choose the latter.

Understanding learning as a problem solving task, individuals use additional thinking strategies and related data that, in many cases, are optional or complementary alternatives to a prescribed process (Carroll, 1979). Rather than interfere with learning, these options can be used to enhance performance. By capitalizing on their aptitudes and compensating for inaptitudes, learners should use these abilities to move beyond given objectives and strategies. Prescribed conditions should not preclude eclectic thinking.

The example given in Figure 2 demonstrates how an elementary school teacher used divergent production to solve the shaded-square problem. Since the teacher had not worked for many years with the arithmetic computation, she needed to think longer on it than someone able to do the convergent thinking illustrated in Figure 1. We might say that she learned how to solve the problem by generating ideas and by associating them in many ways.

Question: What part of the square is shaded?
Respond with many ideas.



Response: 1) Find, e.g., square inches

$10 \times 10 = 100$ sq. in
$3 \times 6 = 18$ sq. in.
5.9%

$10 \overline{)\,100}$ → 10

$18 \overline{)\,100.0}$ → 5.9, 90, 10 0

2) Find % of square -- $5 \times 5 = 25$ $\frac{1}{4}$

But how?

Obviously it is more than 5%. $25 \overline{)\,100}$ → 4 $\quad 100 \overline{)\,25.000}$ → .2

Answer 3) 18%? $100 \overline{)\,18.000}$ → .180

Figures 2 Idea production on the shaded-square problem

Notice that the divergent-response strategy was effective even though the problem was largely convergent. The student stated the problem in more than one way (square inches and percent) and made comparisons among her responses that led to additional ideas. Her own evaluation was helpful, whereas acceptance or disapproval from someone else usually interferes with independent thinking.

Another example illustrates the role that divergent production plays in the learning process. A ten-year-old boy asked for help to change "three-hundred-four thousandths" to a decimal numeral. Guessing resulted in 304., .304, and 30.4. He intuitively stated the problem as, "Where shall I put the decimal point?" When he was asked to choose the best response, he pointed to .304. It is important for the child to know that he generated the possibilities and chose the correct answer himself.

Learners who value their ideas as steps toward academic objectives and invention do not put their ideas on "scrap paper." Written lists of ideas present an opportunity for an evaluation of personal thinking processes as well as content. This uniqueness is valuable to the thinker and is not found elsewhere.

When groups use brainstorming as a format for solving problems, rules are established to facilitate fluency and originality:

1) All ideas are accepted, even repeated ideas.

2) Criticism is deferred.

3) Free-wheeling is encouraged.

Groups stay on task when a leader occasionally repeats the question under consideration and, if necessary, suggests new categories. Multiple idea production is used at each step of the problem solving process. In the beginning, nearly all participants enjoy the fun of calling out freely and

of seeing the unexpected ideas that they produce. Outstanding results, however, often require persistence and disciplined efforts as well as freedom and excitement.

From Divergence to Learning, to Implementation

Before true problem solving will be effective in the classroom or clinic, we need to resolve the dichotomy that has existed between divergent production and academic learning. At this time, creative and career accomplishments do not correlate well with intelligence test scores (Wallach, 1976; Wallach & Wing, 1969), and hence, with achievement test performance. Divergent production, however, might be the element that makes learning functional in both school and career situations. That is, productive thinking stimulates learning and how to use it in new ways.

The assumption is based on the following observations. First, the characteristics of divergent production have been identified (Guilford, 1967). They are accompanied here with applications to learning.

1) Fluency: listing many ideas. Abundant idea production increases time on task, provides data for new options, prompts rehearsal of learned performance, and promotes simultaneous processing of information.

2) Flexibility: presenting ideas in different categories. Different points of view break habits that interfere with new learning and invention.

3) Originality: listing ideas that learners have not heard from other persons. Fresh combinations of ideas lead to improvements on former perceptions (Parnes & Meadow, 1959) and tie new data to old.

4) Elaboration: adding details and filling gaps. Unsolicited ideas explain or extend core concepts.

Many studies show that individuals and groups can develop these characteristics (Torrance, 1976).

The second observation is that the relationship between divergent production and creative ability has been supported widely (Guilford, 1967; Koestler, 1964). The complexity of creativity suggests that although divergent thinking abilities are not sufficient, some of them at least are necessary conditions for the generation of creative products. Similarly, learning involves divergent thinking when it represents changes in learners or indicates that they have used information in new ways.

Lastly, there is support for the effects of creative problem solving that are presented in Figure 3. Guilford (1967), Piaget (Flavell, 1963), Bruner (1960) and Parnes et al (1977) are some of the primary contributors to this research.

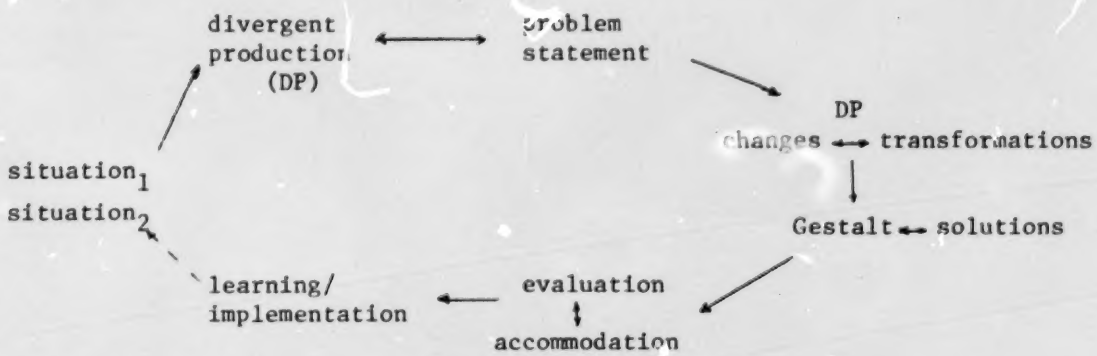


Figure 3 Divergent production within the learning cycle

Whereas academic situations require transformations that are convergent, career situations often call for unexpected outcomes and performance for which individuals have not been prepared. In unforeseen situations, divergent production prompts learners to produce and invent strategies for action and to generalize the effects of training (Campione & Brown, 1979).

If the self-assurance and initiative wrought by divergent thinking were developed early enough, school-related anxiety and learned helplessness

(Henderson, 1980) might diminish considerably. Poor and minority children who answer impulsively (Zelniker & Jeffry, 1976) and women who avoid mathematics (Fox et al, 1977), for example, should make many guesses and then evaluate their own ideas. The switch from "Don't guess" to "Give many possible ideas" takes learners away from a sense of failure to one of attributing success to themselves.

Since classroom instruction has been dominated for years by cognition, memory, and convergent production, however, it is difficult to know how much most students would benefit academically from sustained opportunities to learn through divergent thinking. Few studies (Feldhusen et al, 1969) have been attempted. An historical-cultural bias against multiple response and independent student action confounds controlled studies, and the shift from test performance to the learning processes that underlie subject matter achievement is only beginning.

Experimental evidence will be wanting until learning is defined in terms of intellectual abilities. The work of Sternberg (1979) and others offers promising directions toward this goal. Another encouraging sign is the notable progress made at the SOI Institute[1] directed by Mary Meeker. The Institute is beginning to publish tests and interpretations of results that lead to a complete diagnosis of learning abilities and related prescriptions that influence academic achievement and career performance.

Other progress has been made among learners in special education. Mentally retarded youngsters have demonstrated that they can produce ideas (Ford & Renzulli, 1976), and tell instructors which learning strategies

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[1]SOI Institute, 343 Richmond, El Segundo, CA 90245

work for them (Ozer, 1977). There is evidence, too, that learning under varied conditions and with extended thinking-time transfers to the everyday world better than ample repetition of a singular process (Payne, 1980). The many ways in which individuals are gifted have also been recognized (Marland, 1972). Educators and psychologists are now more concerned about the specific mental abilities that learners have than with degrees of intelligence indicated by a single test score.

Mental Abilities and Locus of Control

How do students learn vocabulary and how do they learn to do analogies and quantitative reasoning? Searching for a new prototype of intelligence that is a catalyst for instructional planning, Sternberg (1979) proposes four levels: (1) a description of tasks, (2) a description of subtasks, (3) an isolation of components or intellectual processes and representations, and (4) a description of metacomponents that influence mental abilities and learning. Metacomponents are the decisions that learners make about which components and representations to use, and the speed and accuracy that will be acceptable for performance. Divergent production is a component or intellectual operation, and the decision to use it is a metacomponent.

The suggestion that learners make internal decisions that govern thinking (Flavell, 1979) depends upon a cognitive model of learning, and therefore, on an internal locus of control. Since few learners generate relations between information and experience automatically, however, it is necessary "to ask them" to do it (Wittrock, 1979). This is a gap that practice with metacognition and divergent production can fill. Idea production dramatizes the position of learners as the main cause of their

behavior, and success with it encourages them to assume responsibility for their own learning.

Part of the responsibility comes in the different ways in which learners process information between questions and performance. Learners do not all use the same information processing strategies, nor do they internalize information in the same way. Some have a tendency to generalize, others to analyze; and general conclusions about "what makes sense" differ among cultures. Resnick (1976) cites the case of children from one culture who are more apt to classify objects according to static categories (food, clothing, tools, cooking utensils) and in another culture according to the action that one object has on another (a knife cuts an orange). Individuals should know their thinking habits and determine whether or not they wish to retain them, or to choose functions appropriate for given tasks.

An example of independent learning is presented in Figure 4. Not only did the student express satisfaction with herself as the one responsible for the change of behavior, she also was aware that her production of ideas replaced algorithms.

Task: Simplify 2/3 x 9/15. Produce many ideas about it.

Response:

multiply	2 will not go into 9, 3, or 15
x sign	3 goes into 9 three times
fractions	9/15 can be "reduced"
line divides two numbers	9/15 is the same as 3/5
equal sign	3/5 is not as large as 2/3
requires an answer	2 x 9 is divisible by 9
smaller numerals on the top	3 x 15 is divisible by 9
3 goes into 9 and 15	I got the answer without doing the computation! 2/5

Figure 4 Idea production for independent learning

Students can use the lists that they produce about a topic as indicators of subject matter achievement and self-help. Counting the number of ideas that they produce, learners have a visible indication of effort. Ideas in different categories demonstrate conceptual depth, and originality often points to creative accomplishment. If learners claim that the ideas that they produce are new or original unto themselves, they can also claim the change of behavior that we call "learning."

Brainstorming lists can be examined for the following levels of thinking when they are used as instructional tools and as a means of performance evaluation:

i) Few responses are listed. The correct answer, if there is one, might be the only response listed by the student.

ii) Many responses are listed; the correct answer is not among them. Ideas that suggest transfer learning and creative uses for ideas are accepted.

iii) Many responses are listed, including the correct answer. Flexibility and originality are low.

iv) Many responses include the correct answer along with much flexibility, originality, and elaboration. There may be signs of invention, implications, unusual transformations, applications, global perceptions, and detail.

The list of responses generated for the simplification of 2/3 x 9/15 in Figure 4 is at the third level. Figure 5 shows a list of ideas produced by an adult on the shaded-square problem, and illustrates responses at the first level. It is likely, however, that thinking longer on the topic would have resulted in an acceptable solution to the problem.

1) part of a whole, a fraction

2) smaller from larger

3) 6 + 6 + 3 + 3 = perimeter = 18

   10 x 4 = perimter = 40

4) 6 x 3 = 18 = area

   10 x 10 = 100 = area

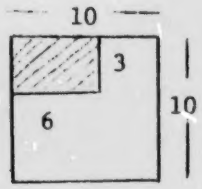

Figure 5 Idea production curtailed before a solution was obtained on the shaded-square problem

Two courses of action might be taken to help this student: (1) instruction on formulas for perimeter and area or (2) instruction on how the learner might stimulate her own ideas further as possibilities for a solution. Once the problem is stated, preferably by the learner, a few prompts encourage the generation of original ideas. "Say whatever you are thinking. Say it roughly." "Use numbers to tell what you see." "Guess, and write or draw." In the beginning, instruction includes frequent directives "to say many things about it." "Say what no one else would say."

A question arises over whether or not learners have the right to select thinking operations and styles of learning. Should students who value divergent production and excel in it be instructed how to use it for academic gain? When the time comes that learners use biofeedback to help them regulate attention and emotion (Brown, 1974), they should also be able to select intellectual operations. Individuals should know their strengths, favorable conditions for their use, and strategies for monitoring their effectiveness.

We can only guess whether or not divergent production would effect growth from the concrete to formal stage of development. Currently, the

majority of learners who attend our schools do not take this step (Weber, 1980; Piaget, 1972). If divergent production and metacognition became habitual, however, these mental abilities may help learners to abstract concepts and to think about thinking. The key to adult learning may be inner control and teacher-acceptance of learners' ideas during childhood. These are new dimensions of learning for most students.

Creative Growth

It is instructive to view learning as different kinds of creativity that relate directly to systemic growth. A quality of learning can be measured then by the creative stage in which individuals contribute to their own learning. Learners who synthesize information are at a different level than those who only enlarge or modify what they see. Knowing the stages, learners can produce ideas to show creative growth in themselves as well as in their products.

Creative stages (Land and Kenneally, 1977) and examples of academic and life problem-solving situations are presented in Figure 6.

Creative Stage	Description	Academic Example	Life Example
enlargement	increase in size, number, structure	arithmetic multiplication, government	longer working hours
modification	substitution, deletion, rearrangement	change "y" to "ies"	time schedules
synthesis	meaning expressed in metaphor or combinations	machinery of politics, the topic sentences of paragraphs	communication systems, Gestalt perception
transformation	high-level invention; change in meaning, position, or form	theory of relativity, parallelogram into a rectangle	1940-1980 international relationships, career changes

Figure 6 Stages of creative growth

Although all of the four stages contribute to learning, the latter one is key to significant changes of behavior. Transformations call for a break-down of current information or of former habits before new ideas can be formulated into a concept or skill. Galileo uprooted information about the solar system under severe challenge, and justice is established only after prejudice is wrenched from its source. Pain from relinquishing habits and ideas accompanies even the correction of spelling errors. Since learners prize what they know, changes in their "possessions" calls for a positive disposition toward transformation. Familiarity with creative growth patterns, however, should soften the emotional adjustments that tend to inhibit much learning.

Sources of growth also need to be recognized. Although changes on planned or organized data are usually produced through conscious thinking, ideas are formed as well through a passive nonconscious awareness when information is incomplete or disorganized. Arieti (1976) attributes these ideas to unconscious or irrational forces. Establishing a rhythm between both conscious and nonconscious "thinking" taps potential that is essential for maximum use of the overt and creative processes required for learning.

If learners could capture the intuitive ideas that come from thinking aside or from relaxed participation (Alten, 1979), they would increase the part that they play in the learning process. One technique that combines active and passive instruction is called Suggestive-Accelerated Learning and Teaching (Caskey, 1980). The process frees what learners can bring to instruction and reinforces new learning through the use of many senses and ways to process information.

Image-making is another technique that helps some learners generate ideas. Producing an abundance of mental images can have much the same effect as brainstorming with words on paper. Images are analogies that are as important as logical concrete objects (Shepard, 1978). More than a picture, they abstract information to aid conceptual development.

Learners who can draw images preserve their ideas in a mode of expression that is not encumbered by cultural ties to language or reading. Before they settle upon a specific image or model for development, however, learners should draw many sketches quickly in the way that artists do. This develops a holistic sense of what they are about prior to a concentration on analysis or elaboration.

Although research on intuition and other nonanalytic abilities is yet in its infancy, there is growing interest in holistic processing and creative strategies associated by some with the right hemisphere of the brain or with interhemispheric collaboration (Bogen & Bogen, 1969). In practice, however, there is resistance to intuitive and creative learning that stems, in part at least, from a perceived lack of teacher control. When teachers sequence learning and monitor performance closely, they sense that they are in control of the learning process. When students produce original ideas, the results are not as predictable and are not likely to follow a predetermined design.

A Prescription of the Future

Divergent production will stimulate learning and transfer when creative thinking is developed within school curricula and clinical programs (Dirkes, 1978). Its effectiveness depends in part upon elimination of the following inhibitors:

1) Concept development is overshadowed by practice. Learners are directed toward immediate short-term goals instead of cognitive growth.

2) Evaluation occurs after each student response and is accompanied by rejection of "errors," thereby dampening the production of alternatives and of student-evaluation of trials.

3) Confidence in the ability of students to produce ideas is rare and reward for original ideas is neglected.

4) Time constraints imposed on responses in large group instruction preclude multiple-idea production.

5) Where brainstorming occurs in the classroom, it is divorced from subject matter development and true problem solving.

6) Discovery learning is confined to convergent outcomes.

7) Measures of ability depend upon traditional test items that can be scored easily.

A decision to diminish or transform these practices is based on the conviction that learners are individuals. Since memory storage, mental abilities, and information processing are unique, learning is unique. Divergent production is used to maximize learning by increasing time on task, thereby prompting individual recall and manipulation of ideas. With deferred evaluation, idea production stimulates independent problem solving that extends to situations outside the classroom. The goal is to help individuals produce ideas that respond to academic and career situations in new ways.

Many techniques can be used to insure this outcome:

1) Learners state problems, e.g. what they set out to do or learn.

2) Fluent independent thinking is encouraged and rewarded.

   Learners produce ideas in different conceptual categories and in different content, i.e. verbal, figural-spatial, symbolic, and behavioral.

All ideas are accepted when they are given; evaluation is deferred.

Passive relaxation is used to stretch the imagination and to permit additional ideas to surface.

3) Learners evaluate their own ideas against a criteria and whether or not they have learned.

4) Individuals implement their ideas.

5) A distinction is made between divergent and convergent production, between uninhibited brainstorming and traditional question-answer procedures, and between the production of original ideas and the reproduction of the ideas of others.

The complexity of learning and living in the unknown future underscores the necessity of learning to think and of thinking to learn. Divergent production helps individuals to learn when they have not been instructed and to solve problems when they do not know what to do. These abilities enable learners to develop their own uniqueness and to contribute to their world. The future will demand no less.

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